Misc. Report #5.

RS - LS
REGENERATION
Planting
(Pelleted Seed)

June 14, 1949

PELLETED SEED FOR REFORESTATION

By Paul O. Rudolf
Lake States Forest Experiment Station 1/

Reforestation by means of pelleted seed sown directly in the field has attracted much interest recently. In 1947 the Station participated in a small test which showed no advantage for pelleting. However, several new pellet materials and techniques have been developed recently, so that further exploratory tests are desirable.

As a basis for planning new tests of pelleted seed, all agencies known to have conducted such work have been contacted. The information obtained from them is summarized here.

PURPOSES OF PELLETING

Pelleting seed is not a new idea. It has been tried intermittently on a small scale at least since the time of the First World War. However, large scale use and commercial pelleting did not arise until the Second World War. It was tried then by the sugarbeet industry in connection with the development of drill seeders capable of very accurate sowing.

There are two main purposes of pelleting seed: One is to provide more economical use of seed through better control of distribution in sowing, and the other is to provide favorable conditions for seed germination on the soil surface. For reforestation the greatest advantage probably would be the possibility of establishing seed spots without the development of multiple seedlings. If at the same time pellets could be developed which provided protection of the seed and seedling from damage by rodents, birds, disease organisms and other enemies while fostering good germination, this would be so much added advantage.

METHODS OF PELLETING

A variety of materials has been tried for making pellets. Ideally a pellet material should be easy to handle in rapid processing, should not be injurious to the seed either before or after germination, should be sufficiently firm to permit reasonable handling in seeding apparatus (and in some cases airplane seeding), yet should disintegrate under favorable moisture conditions rapidly enough to avoid hindrance to seed germination, and it should be reasonable in price. Aside from these characteristics, a pelleting material should also permit the addition of nutrients, repellents, insecticides, fungicides, or hormones.

1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Minnesota, University Farm, St. Paul, Minnesota.

The most common pelleting materials are clays of various kinds. Aside from local clays, these include modelling clay, ball clay, kaolin, and montmorillonite (a soft clay-like mineral of hydrous aluminum silicate). In addition, the following materials also have been used alone or in various mixtures with or without clays; ground rattle bush bean, plaster of Paris, tung nut pomace, dextrin, powdered foamglass, dithiobiuret, anthraquinone, feldspar, fly ash, and diatomaceous earth. To these materials there have usually been added various rodent repellents and frequently also fertilizers, fungicides, insecticides, or growth hormones.

Pelleting Processes

Many pellets for small scale tests have been made by hand. However, this is too expensive for large scale work, so several commercial processes have been developed. These are of two general types; accretion processes in which the pellets are built up by adding successive layers of material, and pressure processes in which the seeds and pelleting material are forced through openings. Three companies are now known to produce commercial pelleted seed. They are: The Filtrol Corporation of Los Angeles, California; the International Seed Pelleting Company of Phoenix, Arizona; and Processed Seeds, Inc., of Midland, Michigan.

Apparently the first in the field was Processed Seeds, Inc., which has operated under different names (Chemi-Coat Seed Company, American Seed Processing Company) since its inception during World War II. The seeds are coated in a machine which superficially resembles a cement mixer. As the spherical shaped pan rotates at about 45° from the vertical the seeds are tumbled over one another. The seeds are moistened with an adhesive (methyl cellulose) and then powdered material is added (feldspar and fly ash) which adheres to the adhesive covered seed. After the coat has dried, successive coats are added until the pellet is the desired size. Fertilizers, repellents, and other materials can be added and pH can be controlled as desired. Pellets of Douglas-fir and presumably most other conifers are elliptical in shape. Recent quotations for pelleting in large batches (seed furnished by customer) range from $.14 per pound for seeds like white pine to $.20 for those like spruces and firs.

The International Seed Pellet Company uses a process developed by Dr. L. S. Adams, its founder. Seeds are mixed with adobe clay which is placed in a machine consisting of four gear-like wheels which mesh in such a manner that a moist seed-filled clay mix is pressed from four sides into spherical balls at rates reported up to 48,000 per hour. These pellets were designed especially for aerial seeding of grasses.

The Filtrol Corporation develops their "Filcoat" pellet from a highly colloidal aluminum silicate (montmorillonite). Seeds are placed in a drum and moistened by a spray of water. Then the coating material is added and the seeds are tumbled about. The addition of moisture and coating material is continued until the pellets are of proper size (Douglas-fir pellets are 1/4 inch in longest diameter). The pellets are screened to get uniform size and then are dried by forcing a large volume of air across them. If the humidity is high, the air is heated to about 10 degrees F. above atmospheric temperature. Repellents, fertilizers, and such materials can be added and pH controlled as desired. The cost of pelleting Douglas-fir seed has just about equaled the cost of the seed.

Related Processes

Several other methods of coating seeds were tried at the Pacific Northwest Forest and Range Experiment Station. These were pressure-formed tablets (calcium carbonate), gelatin capsules, hand-rolled pills (powdered sugar), machine-rolled pills (powdered sugar), and triturate tablets (powdered sugar). For one reason or another all proved unsatisfactory. The Crown Zellerbach Company is trying capsules containing Flowerite and vermiculite with seeds, fertilizers, growth hormones, and fungicides.

A graduate student (Joe Clark) at the University of Washington has developed a tablet which, along with 2 seeds, includes leaf mold, Douglas-fir bark, peat moss, and redwood bark reduced to definite sizes. Apparently somewhat similar were the briquets developed by Dr. S. A. Wilde at the University of Wisconsin several years ago. These were compressed peat, seed, and nutrients.

Good and Bad Features of Various Pellets

For either aerial or ground seeding the added weight of pellets carries the seed through brush, leaves, and grass and gives it a better opportunity to reach the soil and take root. Pelleting permits better control of smaller seeds. A general disadvantage is the added bulk and weight of pelleted seed. This varies considerably. Jack pine seed in pellets of one type weighed 9 times the amount of bare seed. Douglas-fir seed increased in weight about 20 times when pelleted by another process; and certain grass seeds pelleted by a third process weighed 920 times as much as when bare.

Certain kinds of pellets have disadvantages for certain purposes. The Processed Seeds Company type has not been hard enough for use in the walking-stick planter developed in the Pacific Northwest. The International Seed Pelleting Company type may be sufficiently irregular in shape to cause excessive wear on some aerial seeding equipment and the pressure used in the process may injure the seed. Tests at the Intermountain Station have showed injury to 42 percent of the seed in pellets of this type.

SPECIES TESTED AND RESULTS

According to information available, the seeds of over 20 range plants and about 18 forest tree species have been tested in pelleted form (Table 1). The range species, chiefly grasses and legumes, include the following: purple alfalfa, smilograss, big bluegrass, canby bluegrass, mountain brome, smooth brome, soft brome, California bur-clover, tomcat clover, sweet clover, sand dropseed, Ehrharta calycina, foxtail (arundinaceous), Harding grass, Lehmann lovegrass, sand lovegrass, weeping lovegrass, Wilman lovegrass, California needlegrass, hyaline needlegrass, common ryegrass, Wimmera ryegrass, timothy, crested wheatgrass, and western wheatgrass. The tree species tested are Douglas-fir; balsam, noble, and Pacific silver firs; western hemlock; jack, loblolly, longleaf, ponderosa red, slash, eastern white, and western white pines; Port-Orford cedar; and black, Norway, Sitka, and white spruces.

Range seeding of pelleted seed has been quite extensive. Over 90,000 acres has been sown aerially on Indian reservations in Arizona alone, and the Southwestern Region of the Forest Service has contracted for similar sowing of 6,400 acres this spring (1949). Altogether, aerial seeding, broadcast

seeding, and drill seeding have been tried on several types of land and soil conditions. So far, results usually have been poor, and only fair at the best. Pelleted seeds have done no better than bare seeds, and in some cases have done worse. To be equal economically, grass seed would have to increase in cost at least three times (for some species), or the present cost of pelleting would have to drop to about 1/4 of what it is, was the conclusion reached from one set of studies.

The results with sowing pelleted tree seeds have been predominantly poor, occasionally fair, and rarely good. In one case only have pelleted seeds given results better than those with bare seeds. Usually they were about the same, but in several instances they were worse. Seeding has been done in many localities, on prepared and unprepared ground, broadcast (by hand or from airplanes) or in seedspots; in the laboratory, nursery, or field -- none of the methods tried can yet be called successful. The most extensive tests have been made in Ontario where several hundred acres have been sown with pelleted seed, both by airplane and ground methods.

A major stumbling block, both with range and forest species, has been the inability to find a uniformly successful rodent repellent which could be incorporated in the pellets. Several agencies are searching for such repellents and success may attend their efforts at any time.

RECOMMENDATIONS FOR FURTHER STUDIES

Since no highly promising leads have developed from research to date, the time does not seem ripe for large-scale studies with pelleted seed. However, further exploratory studies do seem desirable to test additional species, to sample more conditions, and to try new kinds of pellets or additional repellents and other additives as they become available. In all tests it would be desirable to protect part of the spots from birds and rodents and to sow bare seeds of the same lots as controls.

Table 1.- Results of pelleted seed tests. [2]

Species	Pelleting materials	Source of Pellets 1/	Methods of sowing	Results	Compared with controls	Agency making test
			Range Plants			
Grasses and legumes 2/	Montmorillonite, and montmorillonite plus inert filler	1	Broadcast sown on various types of land	Poor to fair	No better	S.C.S.
Grasses and legumes 3/	Clay and fertilizers plus rodent repellent	2	Aerial seeding	Poor to fair	No better	U.S.I.S.
Grasses (mainly crested wheat grass)	Clay	2	In laboratory and field	Poor	Worse	Int.F. and R.E.S.
Lehmann, sand, and Wilman lovegrasses	Clay	2	In field	Poor	No better	S.W.F. and R.E.S.
Range plants	Clay	2	Broadcast and drilled in field	Poor	No better	Bur. Land Mgt.
			Forest Trees			
Douglas-fir	Montmorillonite; feldspar and fly ash	1, 3	In field plots	Poor	No better	P.N.W.F. & R.E.S.
	Raw clay plus repellents	4	Outdoor flats and field plots	Fair to good	No better	F.W.S.
Balsam fir	Feldspar and fly ash	3	In field plots	Poor	Worse	Cons. W. & P. Co.
Noble fir	Montmorillonite; feldspar and fly ash	1, 3	In field plots	Poor	No better	P.N.W.F. & R.E.S.
	Raw clay plus repellents	4	Outdoor flats and field plots	None	No better	F.W.S.
Pacific silver fir	Raw clay plus repellents	4	Outdoor flats and field plots	None	No better	F.W.S.
Western hemlock	Montmorillonite	1	Seed spots in field	Poor to fair	No better	Crown-Zellerbach
	Montmorillonite; feldspar and fly ash	1, 3	In field plots	Poor	No better	P.N.W.F. & R.E.S.
	Raw clay plus repellents	4	Outdoor flats and field plots	Poor to fair	Worse	F.W.S.

Species	Pelleting materials	Source of Pellets 1/	Methods of sowing	Results	Compared with controls	Agency making test
Jack pine	Clay and other materials 4/	4	In laboratory flats	Poor	Worse	F.W.S.
Loblolly pine	Clay and fertilizers, fungicide and repellent	4	In field and green house	Fair	No better	Champion Fiber
	Montmorillonite; feldspar and fly ash	1, 3	Sown in nursery	Poor	Worse	Miss. F.S.
Longleaf pine	Montmorillonite; feldspar and fly ash	1, 3	Sown in nursery	Poor	Worse	Miss. F.S.
	Clay and fertilizer; fungicide and repellent	4	In field and green house	Fair	No better	Champion Fiber
Ponderosa pine	Not reported	-	In field--screened and unprotected	Fair	No better	F.W.S.
Red pine	Feldspar and fly ash	3	Sown in nursery	Poor	Worse	M.S.C.
	Diatomaceous earth and fly ash	4	In field	Poor	Worse	Ont. Dept. of Forest & Lands
Slash pine	Feldspar and fly ash	3	In field on prepared or unprepared ground	Poor	Worse	Fla. F.S.
	Montmorillonite; feldspar and fly ash	1, 3	Sown in nursery	Poor	Worse	Miss. F.S.
Eastern white pine	Feldspar and fly ash	3	Sown in nursery	Poor	Worse	M.S.C.
	Diatomaceous earth and fly ash	4	In field	Poor	Worse	Ont. Dept. of Forest & Lands
Western white pine	Local clay	4	In field	Fair	No better	Kaniksu N.F.
Port-Orford cedar	Montmorillonite	1	Seed spots in field	Poor to fair	No better	Crown-Zellerbach
Black spruce	Feldspar and fly ash	3	In field plots	Good	Better	Cons. W. & P. Co.
Norway spruce	Feldspar and fly ash	3	Sown in nursery	Poor	Worse	M.S.C.
Sitka spruce	Montmorillonite	1	Seed spots in field	Poor to fair	No better	Crown-Zellerbach
	Montmorillonite; feldspar and fly ash	1, 3	In field	Poor	No better	P.N.W.F. & R.E.S.
White spruce	Feldspar and fly ash	3	Sown in nursery	Poor	Worse	M.S.C.

Species	Pelleting materials	Source of 1/ Pellets	Methods of sowing	Results	Compared with controls	Agency making tests
White spruce	Feldspar and fly ash	3	In field plots	Poor	Worse	Cons. W. & P. Co.
	Diatomaceous earth and fly ash	4	In field	Poor	Worse	Ont. Dept. of Lands & Forests

º Please do not quote any results without clearance from agency making the tests.

1/ 1 = Filtrol Corporation, 2 = International Seed Pelleting Company, 3 = Processed Seeds, Inc., 4 = locally made.

2/ Included Alopecurus arundinaceus, Bromus mollis, B. carinatus, Ehrharta calycina, Eragrostis lehmanniana, Lolium multiflorum, L. subulatum, Medicago hispida, M. sativa, Oryzopsis miliacea, Phalaris tuberosa stenoptera, Poa ampla, P. canbyi, Stipa hyalina, S. pulchra, Trifolium tridentatum.

3/ Eragrostis lehmanniana, E. curvula, Sporobulus cryptandrus, Agropyron Smithii, A. cristatum, Bromus inermis, Melilotus sp., and Phleum pratense.

4/ Ground rattle bush bean, plaster of Paris, tung nut pomace, kaolin, dextrin, modelling clay, ball clay, powdered foamglass, dithiobiuret, anthraquinone, and compound No. 11-317 used in combinations.

APPENDIX A 1/

Experiments with Range Plants

1. Agency - Soil Conservation Service, Southern California Nursery Unit, San Fernando, California.

2. Species tested - Grasses and legumes: Alopecurus arundinaceus, Bromus mollis, B. carinatus, Ehrharta calycina, Eragrostis lehmanniana, Lolium multiflorum, L. subulatum, Medicago hispida, M. sativa, Oryzopsis miliacea, Phalaris tuberosa stenoptera, Poa ampla, P. canbyi, Stipa hyalina, S. pulchria, Trifolium tridentatum.

3. Pelleting materials - Done by Filtrol Company. Used two types: 100 percent montmorillonite (the special clay used) and another with an inert filler added to the montmorillonite.

4. Techniques used - Broadcast seeding on various types of land.

5. Results - Long brittle seeds injured in pelleting.

   a. Poor results on difficult sites in drought year with all kinds.

   b. On Class III land no advantage over untreated seed.

   c. On better range lands, germination fairly good -- results not yet final for comparison.

6. Recommendations

   a. Pellets of cheto plus inert filler can be extruded with less pressure and hence with less injury to seed.

   b. Use more than one seed per pellet -- usually happens in extrusion.

   c. Die hole for pellet should have diameter greater than long axis of seed.

   d. Pellet material should take up water readily but be sufficiently cohesive to make disintegration a slow process.

   e. Include rodent repellent with meaty seed, such as most tree seeds.

   f. Possibly use fertilizer and fungicide in pellet also.

7. Reporter - Lowell A. Mullen, Agronomist.

8. Date - January 27, 1949

1/ Please do not quote any results without clearance from agency making the test.

1. Agency - Papago Agency, U. S. Department of Interior, Sells, Arizona.

2. Species tested - Lehmann's lovegrass (Erogrostis lehmanniana) and sand dropseed (Sporobolus cryptandrus); have small seeds (3 million to 7 million per pound) which are easily destroyed by insects and rodents.

3. Pelleting materials - Clay with small amounts of fertilizer and rodent repellent. Pellets were size of garden pea and contained 6-10 seeds. Done by International Seed Pellet Company (Dr. Adams).

4. Techniques used - Seeded from airplane before summer rains in 1946. Seeded over 10,000 acres at altitude of 2,800 to 3,100 feet above sea level. Sowing rate about 1 pellet per square foot of area, or 261,000-436,000 seeds per acre. Soils varied from good to poor -- mostly medium to coarse texture and slowly permeable to permeable, and slopes of 2-8 percent. Some erosion. Chiefly mesquito vegetation.

5. Results - Got about 1,900 plants per acre end of first year, 75 per acre end of second year. Pellets disintegrated after first rain. Many shattered on contact. None penetrated into soil.

6. Recommendations - Prepare ground in advance of seeding. Sow equal areas with untreated seed and with pelleted seed. Don't hold seed long, either in pellets or otherwise, since there is apt to be some deterioration.

7. Reporter - Burton A. Ladd, Superintendent.

8. Date - February 7, 1949.

1. Agency - Office of Indian Affairs, Phoenix, Arizona.

2. Species tested - Lehman lovegrass, sand dropseed, weeping lovegrass, western wheatgrass, crested wheat grass, smooth brome grass, sweet clover, and timothy.

3. Pelleting materials - Materials having 25-27 percent clay fraction because of its favorable colloidal content and cohesiveness for cementing and binding qualities. Sought soils with paucity of quartz grains to avoid wear on pelleting machinery. Organic matter content, fertilizer constituents, and general location near machinery and landing strips also considered. Pellets made by International Seed Pellet Company.

4. Technique used - Aerial sowing.

5. Results - 90,000 acres seeded from April 1946 to August 1948. Results not all available (but generally not too favorable).

6. Recommendations

7. Reporter - W. H. Berry, Regional Soil Conservationist.

8. Date - January 18, 1949.

1. Agency - Intermountain Forest & Range Experiment Station, Ogden, Utah.

2. Species tested - Checked results of Bureau of Land Management tests with grasses, particularly crested wheat grass.

3. Pelleting materials - Pellets averaged .55 grams in weight, 7.6 pH, 1.08 percent salinity, and contained 3-5 seeds (making up 1.09 percent of the pellet weight), of which 42 percent were damaged.

4. Technique used - not reported.

5. Results of tests - Laboratory germination.

	In sand flats 1/	In petri dishes
	Percent	Percent
Whole pellets	4.09	5.67
Whole pellets 2/	6.82	-
Crushed pellets	12.95	-
Undamaged seed from pellets	-	19.52
Damaged seed from pellets	-	2.35
Naked, unpelletized seed	53.75	51.50

1/ Sown 3/8 inch deep.
2/ Sown on surface.

Observations on ground also indicate that pelleting is a detriment and not an advantage in seeding.

6. Recommendations - Await further results.

7. Reporter - Reed W. Bailey, Director

8. Date - January 26, 1949.

1. Agency - Southwestern Forest & Range Experiment Station, Tucson, Arizona.

2. Species tested - Lehman lovegrass, sand lovegrass, Wilman lovegrass.

3. Pelleting materials - Dr. Adams (International Seed Pellet Co.,) method (Clay).

4. Techniques used - Used 8 seed per pellet.

5. Results of tests - Lehman lovegrass pellets germinated 64 percent (but only 1.2 seeds per pellet); sand lovegrass, 15 percent; Wilman lovegrass, 28 percent. Weight makes practice uneconomical, requires a weight lift of 920 pounds as compared to one pound of naked seed. Pelleted seed has yet to establish a satisfactory stand of grass where naked seed has failed in small range plot tests of Lehman, Wilman, and sand lovegrass.

6. Recommendations - Pelleting offers an opportunity for a saving in seed but at the present cost of seed and pelleting, Lehman's lovegrass seed would have to triple in price, or the cost of pelleting would have to decrease to 1/4 of what it is now for economic advantage.

7. Reporter - Raymond Price, Director.

8. Date - November 24, 1948.

1. Agency - Rocky Mountain Forest & Range Experiment Station, Fort Collins.

2. Species tested - Range species.

3. Pelleting materials - Clay, pelleting done by Adams Company (International Seed Pellet Company of Phoenix, Arizona).

4. Techniques used - Broadcast and drilled pelleted and naked seeds on prepared and unprepared seedbeds.

5. Results - Results of Station tests not yet available. Tests by Bureau of Land Management in Wyoming and Idaho, end of first year, showed that pelleted seed gave poorer results than naked seed sown broadcast, and neither gave good stands without seedbed preparation and seed covering, on range lands.

6. Recommendations

7. Reporter - W. G. McGinnies, Director.

8. Date - November 17, 1948.

1. Agency - School of Forestry, University of Idaho.

2. Species tested - Crested wheatgrass and other range species.

3. Pelleting materials - Compression type of pellet from International Seed Pellet Company, and accretion type pellet of Processed Seeds, Inc.

4. Technique used - Sowed seeds both in laboratory and field.

5. Results - Not yet complete. However, accretive type pellets have shown up better in both laboratory and field. Compression type produces considerable mechanical damage to seed and also inhibits germination.

6. Recommendations - Further tests needed.

7. Reporter - E. W. Tisdale, Associate Professor, Range Management.

8. Date - January 18, 1949.

APPENDIX B 1/

Experiments with Forest Tree Species

1. Agency - Dunbar Forest Experiment Station, Michigan State College.

2. Species - Red pine, white pine, white spruce, Norway spruce.

3. Pelleting materials - Done by Processed Seeds, Inc.

4. Techniques used - Sown in nursery seedbed using randomized blocks. Sowing later than desirable.

5. Results - Damping off affected all. In all cases controls were better than treated -- differences statistically significant.

6. Recommendations - Make more comprehensive tests.

7. Reporter - Maurice W. Day.

8. Date - February 11, 1949.

1. Agency - Florida Forest Service.

2. Species tested - Slash pine.

3. Pelleting material - Done by Processed Seeds, Inc.

4. Techniques used - Sowed in three localities over the state in prepared and unprepared soil.

5. Results - Sown late (last of April). No rain for first month and coating disintegrated without seeds sprouting.

6. Recommendations - Further tests planned for this winter; no recommendations until further results available.

7. Reporter - R. A. Bonninghausen, Acting State Forester.

8. Date - January 11, 1949

1/ See footnote on page 1, Appendix A.

1. Agency - Extension Forester, Massachusetts.

2. Species tested - Red pine, Norway spruce.

3. Pelleting materials - Done by Processed Seeds, Inc. (Vogelsang).

4. Techniques used - Planted seed with corn planter.

5. Results - Not yet available.

6. Recommendations - Will try cork oak acorns covered with fiber glass tape next spring.

7. Reporter - Robert B. Parmenter.

8. Date - January 26, 1949.

1. Agency - Champion Paper and Fiber Company, South Carolina State Commission of Forestry, Clemson College, and Camp Manufacturing Company in cooperation.

2. Species tested - Loblolly pine, longleaf pine.

3. Pelleting materials - Clay, superphosphate and potash fertilizer, an adhesive fungicide, and a rodent repellent. Done in machine made for sugar coating pills, manufactured by Arthur Colton Company, 2600 E. Jefferson Ave., Detroit, Michigan (their catalog 11, Section A). Considered economical process.

4. Techniques used - Planted pelleted and unpelleted seeds on 2-3 acre experimental plots from the Upper Piedmont of South Carolina to the coastal plains of South Carolina and Virginia.

5. Results - Mechanics of making pellets economically are well worked out. Field results not yet available. Greenhouse tests with hormones included in pellets gave no particular advantage.

6. Recommendations - More research on pellet ingredients now a hit or miss selection.

7. Reporter - T. H. Davis, Research Forester, Champion Fiber Company, through J. W. Cruikshank, Southeastern Forest Experiment Station.

8. Date - November 24, 1948.

1. Agency - State Forester, Mississippi.

2. Species tested - Pines.

3. Pelleting materials - Pellets made by Filtrol Corporation and Processed Seeds, Inc.

4. Techniques used - Sowed in nursery (Mount Olive).

5. Results - Details not available. In general, results are inferior to those with untreated seeds (check sowings).

6. Recommendations - Further study needed.

7. Reporter - Albert Leggett, State Forester, through P. R. Wheeler, Southern Forest Experiment Station.

8. Date - November 24, 1948.

1. Agency - Kaniksu National Forest.

2. Species tested - Western white pine.

3. Pelleting materials - Clay mud of local origin. No additives.

4. Techniques used - Pelleted by hand. Seeded in comparison with untreated seed.

5. Results - Pelleted seed had no superiority over unpelleted seed.

6. Recommendations

7. Reporter - Donald Lynch, through H. E. Dickerman, Northern Rocky Mountain Forest and Range Experiment Station.

8. Date - November 18, 1948.

1. Agency - Crown Zellerbach Corporation, Portland, Oregon.

2. Species tested - Western hemlock, Port-orford cedar, and Sitka spruce.

3. Pelleting materials - Done by Filtrol Corporation. Coating, including fertilizers, rodent repellents, and growth promoting materials is applied to each individual seed by a continuous non-pressure process. Pellet weighs some twenty times that of bare seed.

4. Techniques used

   a. Seed spots, made with calked shoe or 5-pronged converted garden scratcher, using 4-15 seeds per spot.

   b. Flowerite and Vermiculite (sterile carrier materials which absorb many times their own weight of water and trap and hold air) are being used in capsules with seeds, fertilizers, growth hormones, and fungicides. Results not yet available. Also a tablet has been developed by Joe Clark (graduate student of University of Washington) which includes leaf mold, Douglas-fir bark, peat moss, and Redwood bark reduced to definite sizes, each tablet has two seeds, is treated with fungicide, moistened thoroughly, and then stratified. Results so far inconclusive.

5. Results - Some trees on all areas. Comparison not direct, but most trees were found on area poisoned against rodents, using unpelleted seeds. Greenhouse tests underway are not yet complete. The added weight carries the seed through brush, leaves and grass, giving it a better opportunity to reach the ground and take root. Pelleting allows better control of the smaller seeds, resulting in lower cost per acre for seed as well as lower labor costs, since the pellets are far easier to work with than tiny seeds.

6. Recommendations - Try more tests.

7. Reporter - G. H. Schroeder, Forestry Staff.

8. Date - January 25, 1949.

1. Agency - Fish & Wildlife Service and Lake States Forest Experiment Station, in cooperation.

2. Species tested - Jack pine.

3. Pelleting materials - Pellets:

R-203 Daubentonia drummondii (rattle bush bean) finely ground.
R-204 Daubentonia drummondii (rattle bush bean) finely ground with addition of plaster of Paris.
R-205 Tung nut ponace, plaster of Paris, and dextrin.
R-206 Koalin in plaster of Paris.
R-207 Ball clay and plaster of Paris.
R-208 Modelling clay and plaster of Paris.
R-209 Ball clay and ground tung nut ponace.
R-210 Ball clay and ground Daubentonia drummondii.
R-211 Ball clay and dextrin.
R-212 Ball clay and powdered foamglass.
R-213 Ball clay and dithiobiuret.
R-214 Ball clay and anthraquinone.
R-215 Ball clay and compound No. 11-317.

4. Techniques used - Pellets made by hand (7-10 seed per pellet). Tested in germination room at Lake States Station in sand flats at temperature of 68° F. (night) to 86° F. (day).

5. Results - Germination was not particularly high, ranging from .1 to 2.4 seeds per pellet in 30 days, except that materials R-203, R-209, and R-213 gave no germination. In all but one case (R-208) from 25-75 percent of the remaining ungerminated seeds were spoiled. The condition of the pellets at the conclusion of the germination tests was as follows:

R-205 Pellets tended to break up, although in some cases the pellets were pushed up out of the sand by groups of three or four seedlings. They were somewhat expanded due to soaking with water.
R-206 Quite soft. Pellets not lifted out of sand by germinating seedlings.
R-208 Fairly solid.
R-215 Fairly solid.
R-214 Fairly soft.
R-207 Fairly solid.
R-212 Quite solid. Pellets sometimes pushed up by seedlings.
R-211 Quite solid, in several cases almost hard.
R-204 Expanded to twice original size. Fairly soft. Still holding shape.
R-210 Quite solid. Slightly enlarged. In one case four seedlings had germinated inside but were not able to push out.
R-204 Expanded to twice original size. Mold accumulation on top. Seemed to hold shape.
R-213 Quite solid.
R-209 Fairly solid pellet, sticky when opened.

6. Recommendations - Unpelleted seed gave better laboratory results, so recommendations were to omit pellets in field test.

7. Reporter - R. H. Gensch, Biologist.

8. Date - July 23, 1947.

1. Agency - Research Division, Ontario Department of Lands & Forests.

2. Species tested - White pine, red pine, and white spruce.

3. Pelleting materials - Abandoned Dow formula of 65-35 feldspar and fly ash in favor of 50-50 mixture of diatomaceous earth and fly ash. Have added various fungicides, fertilizers, trace elements, and rodent repellents.

4. Techniques used - Seed coated or pelleted in a tumbler coater. Tried storage in refrigeration at alternating temperatures and with or without moisture. Used airplane seeding on burns, sowing 5,000-10,000 seeds per acre with special seeding device.

5. Results - In 1947 on one area got 1 percent germination, on another got 0.5 percent, and 1 seedling per acre survival. Another showed moderate reproduction which may be largely from remaining seed trees.

6. Recommendations - Other tests are underway; recommendations must await further findings.

7. Reporter - A. P. Leslie.

8. Date - June 1948.

1. Agency - Pacific Northwest Forest and Range Experiment Station.

2. Species tested - Douglas-fir, western hemlock, Sitka spruce, and noble fir.

3. Pelleting materials - Processed seeds (feldspar filler and methyl cellulose solution as binding material), International Seed Pellet Co. (adobe clay), and Filtrol Corporation (highly colloidal aluminum silicate). Also tried were pressure-formed tablets of calcium carbonate, gelatin capsules, non-pressure tablets (of powdered cane sugar), hand-rolled sugar pills, machine-rolled sugar pills, and triturate tablets (also of powdered sugar).

4. Techniques used - Standard techniques of pelleting, etc. Seed-spotting in field, with and without walking-stick planter.

5. Results - On Cascade Head Experimental Forest all species germinated about same in pellets (Processed seeds) as without, but because of dry weather all were below 10 percent -- pellet not hard enough for hand planter. Douglas-fir seed in Filcoat pellet germinated as well as controls or better on the surface of sand but germinated very poorly when buried 1/8 inch in sand. Pelleting cost about 20 cents per M seeds, about same as cost of seed alone.

6. Recommendations - Make further tests.

7. Reporter - Roy R. Silen.

8. Date - June 1948.

1. Agency - Fish and Wildlife Service, Portland, Oregon.

2. Species tested - Western hemlock, Douglas-fir, and true firs (A nobilis, and A amabilis).

3. Pelleting materials - Raw clay matrix with some 40 different rodent repellents.

4. Techniques used - Germination tested in outdoor flats and in field plots, and exposed to white-footed mouse damage. Number of seeds per pellet was 10 for hemlock and 3-5 for the true firs and Douglas-fir.

5. Results - For western hemlock laboratory germination was poor to good in pellets and high for bare seed, while in the field it was 0-3 percent in pellets and 8 percent for bare seed; the fir seed did not germinate in the test period; Douglas-fir seed gave fair to high germination in pellets in the laboratory, about the same as for bare seed. No repellents were effective against white-footed mice.

6. Recommendations - Search for more effective repellent.

7. Reporter - A. W. Moore, Biologist.

8. Date - October 21, 1947.

1. Agency - Consolidated Water Power & Paper Company.

2. Species - Balsam fir, black spruce, white spruce.

3. Pelleting materials - Pellets from Processed Seeds, Inc., made of 65 percent feldspar and 35 percent fly ash, plus fungicide (Arasan), rock phosphate, and keto succinic acid, were neutral in pH.

4. Techniques used - Sown covered and uncovered in seed spots in field, on different sites.

5. Results - One season's results showed less germination for pelleted than for bare seed of balsam fir and white spruce. Pelleted seed did better on moist sites than on dry ones. Pelleted black spruce seed in uncovered spots was almost 100 percent better than bare seed. Pelleted seed sown in spring showed lag in germination.

6. Recommendations - More studies needed, especially trying fall sowing.

7. Reporter - E. S. Hurd, Forester.

8. Date - February 21, 1949.

1. Agency - U. S. Fish and Wildlife Service, in cooperation with California Forest and Range Experiment Station.

2. Species - Ponderosa pine.

3. Pelleting materials - Not stated.

4. Techniques used - Pelleted seed with various repellents added were sown on the Plumas National Forest in seed spots, both unprotected and protected with wire screens. For comparison, bare seeds both stratified and untreated were also sown in the same manner.

5. Results - Because of dearth of rodents they did little damage to any of the seed. Germination was somewhat retarded by pelleting. Stratified seed germinated more promptly and completely than any of the others. In unprotected spots pelleted seed germinated 0-60 percent (average 35 percent) as compared to 30 percent for untreated bare seed and 80 percent for stratified bare seed. In screened spots pelleted seed germinated 10-70 percent (average 42 percent) as compared to 90 percent for untreated bare seed and 100 percent for stratified bare seed.

6. Recommendations - Further tests of repellents needed.

7. Reporter - Joseph Keyes, Biologist, through Jack Welch, Biologist, Fish and Wildlife Service, Denver.

8. Date - February 28, 1949.